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Efficacy and selectivity of pelargonic acid for weed management in soybean and corn crops

Abstract − The objective of this work was to evaluate the efficacy and selectivity of different rates and sequential applications of pelargonic acid, using shielded directed spraying for weed management in soybean and corn. Field experiments for each crop were carried out in a randomized complete block design with four replicates. Treatments consisted the use of active ingredient rates and sequential applications, as follows: single application of 6.5 kg ha^{-1}; single application of 13 kg ha^{-1}; single application of 19.5 kg ha^{-1}; two applications of 6.5 kg ha^{-1}; two applications of 13 kg ha^{-1}; three applications of 6.5 kg ha^{-1}; three applications of 13 kg ha^{-1}; hand-hoed control and unhoed control. The results indicate that effective weed management of soybean require at least three applications of 6.5 kg ha^{-1}, or two applications of 13 kg ha^{-1}. On corn, one application of 13 kg ha^{-1} was sufficient to provide adequate weed control. The use of shielded directed spraying contribute to maintain crop selectivity, while ensuring satisfactory weed control.

Index terms: *Glycine max*, *Zea mays*, bioherbicide, directed spraying, sequential application.

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Eficácia e seletividade do ácido pelargônico no controle de plantas daninhas nas culturas da soja e milho

Resumo − O objetivo deste trabalho foi avaliar a eficácia e a seletividade de diferentes doses e aplicações sequenciais de ácido pelargônico, por meio de pulverização dirigida com proteção, no manejo de plantas daninhas em soja e milho. Os experimentos foram realizados em campo, em delineamento de blocos completos ao acaso, com quatro repetições. Os tratamentos consistiram de: aplicação única de 6,5 kg ha^{-1}; aplicação única de 13 kg ha^{-1}; aplicação única de 19,5 kg ha^{-1}; duas aplicações de 6,5 kg ha^{-1}; duas aplicações de 13 kg ha^{-1}; três aplicações de 6,5 kg ha^{-1}; três aplicações de 13 kg ha^{-1}; testemunha capinada; e testemunha sem capina. Os resultados indicaram que, para a soja, o controle eficiente das plantas daninhas requer pelo menos três aplicações de 6,5 kg ha^{-1} ou duas aplicações de 13 kg ha^{-1}, enquanto para o milho uma única aplicação de 13 kg ha^{-1} foi suficiente para proporcionar o controle adequado. A pulverização dirigida com proteção contribui para manter a seletividade das culturas, garantindo o controle satisfatório das plantas daninhas.

Termos para indexação: *Glycine max*, *Zea mays*, bioherbicida, pulverização dirigida, aplicação sequencial.

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Introduction

Weed interference can reduce soybean [*Glycine max* (L.) Merr.] yield by up to 62% (Arshad et al., 2026), whereas corn (*Zea mays* L.) yield losses may reach 86% (Piazentine et al., 2024), highlighting the need for effective weed management strategies. However, chemical control remains the most widely adopted weed management strategy, which can lead to environmental concerns such as crop injury, nontarget organism impacts, and residual herbicide activity in soil and water (Parven et al., 2025).

Consequently, sustainable weed management has emerged as a major challenge for food producers, particularly in organic systems, due to the limited availability of registered bioherbicides. Pelargonic acid represents a promising alternative for weed control in sustainable agricultural systems, posing a low risk of contamination to nontarget terrestrial organisms, such as birds and mammals, due to this acid natural occurrence and rapid biodegradability (EFSA et al., 2025). Moreover, pelargonic acid is approved for use in organic agriculture in Brazil when derived from natural or renewable sources, such as the oxidative cleavage of oleic acid (Brasil, 2021).

As a fatty acid-based contact bioherbicide, pelargonic acid rapidly disrupts plant cell membranes, leading to cellular leakage, excessive generation of reactive oxygen species, rapid tissue desiccation, and tissue necrosis (Preisler et al., 2026).

Pelargonic acid exhibits a favorable environmental profile, characterized by low-leaching potential in sandy soils with low content of organic matter and high degradability, with a soil half-life of less than one day (Poiger et al., 2024). However, despite the increasing interest in this acid as a bioherbicide, information on its performance under tropical field conditions remains limited, particularly regarding application strategies of this acid that ensure both effective weed control and crop selectivity.

Compared to conventional herbicides, pelargonic acid requires higher application rates to achieve effective weed control (Travlos et al., 2020), as reduced rates often result in poor control and rapid weed regrowth, due to its contact mode of action (Kanatas et al., 2021). Therefore, effective weed management depends on identifying application rates that balance efficacy with production costs (Moraes et al., 2019).

However, higher application rates may also increase the risk of crop injury. Thus, crop selectivity in post-emergence applications of nonselective herbicides can be achieved through protected directed spraying, which minimizes herbicide exposure to cultivated plants (Gholap et al., 2022).

The objective of this work was to evaluate the efficacy of sequential, protected and directed spray applications of pelargonic acid, for weed management and their selectivity in soybean and corn.

Materials and Methods

The experiments were established and conducted in field conditions, at the Universidade Estadual do Oeste do Paraná (Unioeste), in the municipality of Marechal Cândido Rondon, in the state of Paraná, Brazil. The geographical coordinates of the experimental area are 24°40'59"S and 54°16'47"W, at 251 m average altitude. The soybean and corn experiments were carried out simultaneously during the 2022/2023 growing season.

The soil of the experimental area is classified as Latossolo Vermelho Eutrófico, according to the Brazilian Soil Classification System (Santos et al., 2018), equivalent to the Ferralsol. As to physical characteristics, it shows 578 g kg^{-1} clay, 347 g kg^{-1} silt, and 75 g kg^{-1} sand; and its chemical characteristics are the following: 5.09 pH ($CaCl_2$); 29.05 g dm^{-3} OM; 25.93 mg dm^{-3} P (Mehlich-1); 2.10 $cmol_c$ dm^{-3} Mg^{2+}; 0.73 $cmol_c$ dm^{-3} K^+ (Mehlich-1); 5.18 $cmol_c$ dm^{-3} Ca^{2+}; 0.00 $cmol_c dm^{-3}$ Al^{3+}; 8.02 $cmol_c dm^{-3}$ SB; 12.81 $cmol_c dm^{-3}$ CEC; 4.78 $cmol_c$ dm^{-3} H+Al; and 64% bases saturation (V).

The experiments were conducted in a randomized complete block design, with four replicates. Treatments consisted of protected directed-spray applications of pelargonic acid Emerion 7700 (Novag S.A.S), containing 649 g L^{-1} pelargonic acid, including: single application of 6.5 kg ha^{-1} (1AP6.5); single application of 13 kg ha^{-1} (1AP13); single application of 19.5 kg ha^{-1} (1AP19.5); two applications of 6.5 kg ha^{-1} (2AP6.5); two applications of 13 kg ha^{-1} (2AP13); three applications of 6.5 kg ha^{-1} (3AP6.5); three applications of 13 kg ha^{-1} (3AP13); hand-hoed control (HC); and unhoed control (UHC).

Each experimental plot comprised five rows, each 5 m long, whose three central rows (excluding 0.5 m from each end) served as the evaluation area (6 m^2 total). Crops were established via no-till planting, using

a mechanical seeder. The Monsoy 5947 IPRO soybean cultivar was planted into corn residue (3,745 kg ha^{-1}) on October 8, 2022, at 0.5 m row spacing (13 seed m^{-1}), and N-P-K 02-20-18 was applied at 340 kg ha^{-1} as the basal fertilizer. Corn (5,450 kg ha^{-1}) was planted on September 17, 2022, into black oat (*Avena strigosa*) residue that had been mechanically managed with a roller-crimper prior to planting. The Pioneer 3858 PWU corn hybrid was planted at 0.5 m row spacing (3.3 seed m^{-1}), and N-P-K 12-18-12 was applied at 370 kg ha^{-1} as basal fertilizer; at the V_5 stage, the crop received 120 kg ha^{-1} urea applied as topdressing.

Applications were performed using a CO_2 pressurized backpack sprayer, calibrated to deliver 200 L ha^{-1}, equipped with AD 11002 nozzles and napoleon hat-type shields. During applications, environmental conditions including air temperature, relative humidity, and wind speed were recorded using a portable thermo-hygro-anemometer (Table 1).

The first application of pelargonic acid was carried out during the 2-4 leaf growth stages of the weed community. Sequential applications were performed at 10-14-day intervals, after weed regrowth had produced new leaves without visible phytotoxic symptoms.

Weed control efficacy and crop injury were assessed using the visual percentage scale proposed by Velini et al. (1995), where 0 indicates no injury, and 100 represents complete plant death. Plant heights were measured in five plants of soybean (at R_2 growth stage) and corn (at V_{10} growth stage), within the useful plot area, from the soil surface to the last fully expanded leaf, without extending the leaf.

Table 1. Meteorological conditions[(1)] during pelargonic acid applications across different crop development stages in 2022.

Application	Date	AT (°C)	RH (%)	WS (km per hour)	GS
			Soybean		
First	Oct. 28	25.0	70.8	2.3	V_2
Second	Nov. 11	24.0	62.1	1.8	V_4
Third	Nov. 25	26.7	83.7	0.3	R_1
			Corn		
First	Oct. 4	30.8	51.2	0.7	V_2
Second	Oct. 18	26.4	65.1	1.1	V_5
Third	Oct. 28	27.1	67.0	0.3	V_7

[(1)]AT, air temperature; RH, relative humidity; WS, wind speed; GS, growth stage.

Weed assessments were performed at 62 and 136 days after sowing (DAS) for soybean, and 55 and 145 DAS for corn, using one quadrat (0.5×0.5 m = 0.25 m^2) per experimental unit at each evaluation. The quadrat was randomly placed within crop rows in the evaluation area. Weed species were identified in the field based on their morphological characteristics, using the botanical descriptions provided by Lorenzi (2014). Weed samples were then used to calculate relative importance values, considering frequency, density, and relative dominance (Mueller-Dombois & Ellenberg, 1974).

Harvest occurred at 136 DAS for soybean, and 145 DAS for corn. Soybean plants were cut at ground level, while corn ears were collected. After mechanical threshing and grain cleaning, yield (kg ha^{-1}, at 13% moisture) and 1,000-grain weight (g) were determined from eight 100-grain subsamples per plot.

The efficacy of weed control and data on crop-injury were graphically represented across evaluation timings, in which error bars indicate the standard error of the mean. Dry-weed biomass, plant height, thousand-grain weight, and yield data were subjected to the analysis of variance, after verification of the assumptions of normality of residuals (Shapiro-Wilk test) and homogeneity of variances (Levene test). Treatment means were compared using the Tukey test, at the 5% probability, in the SISVAR statistical software (Ferreira, 2019).

Results and Discussion

Single applications of pelargonic acid provided less than 45% weed control in soybean, regardless of the application rate; this limited efficacy was observed from the first evaluation onward (Figure 1 A). The sequential double application of pelargonic acid (6.5 kg ha^{-1}) provided about 70% weed control, at the first evaluation after the second application, although efficacy declined thereafter (Figure 1 C). Similarly, the double sequential application at 13 kg ha^{-1} achieved 80% weed control, which was maintained through 7 days after the second application (DA2A), but declined thereafter due to weed regrowth.

The triple sequential application resulted in excellent weed control (over 90%) at the first evaluation after the third application, regardless of the application rate. This sequential application strategy promoted a progressive

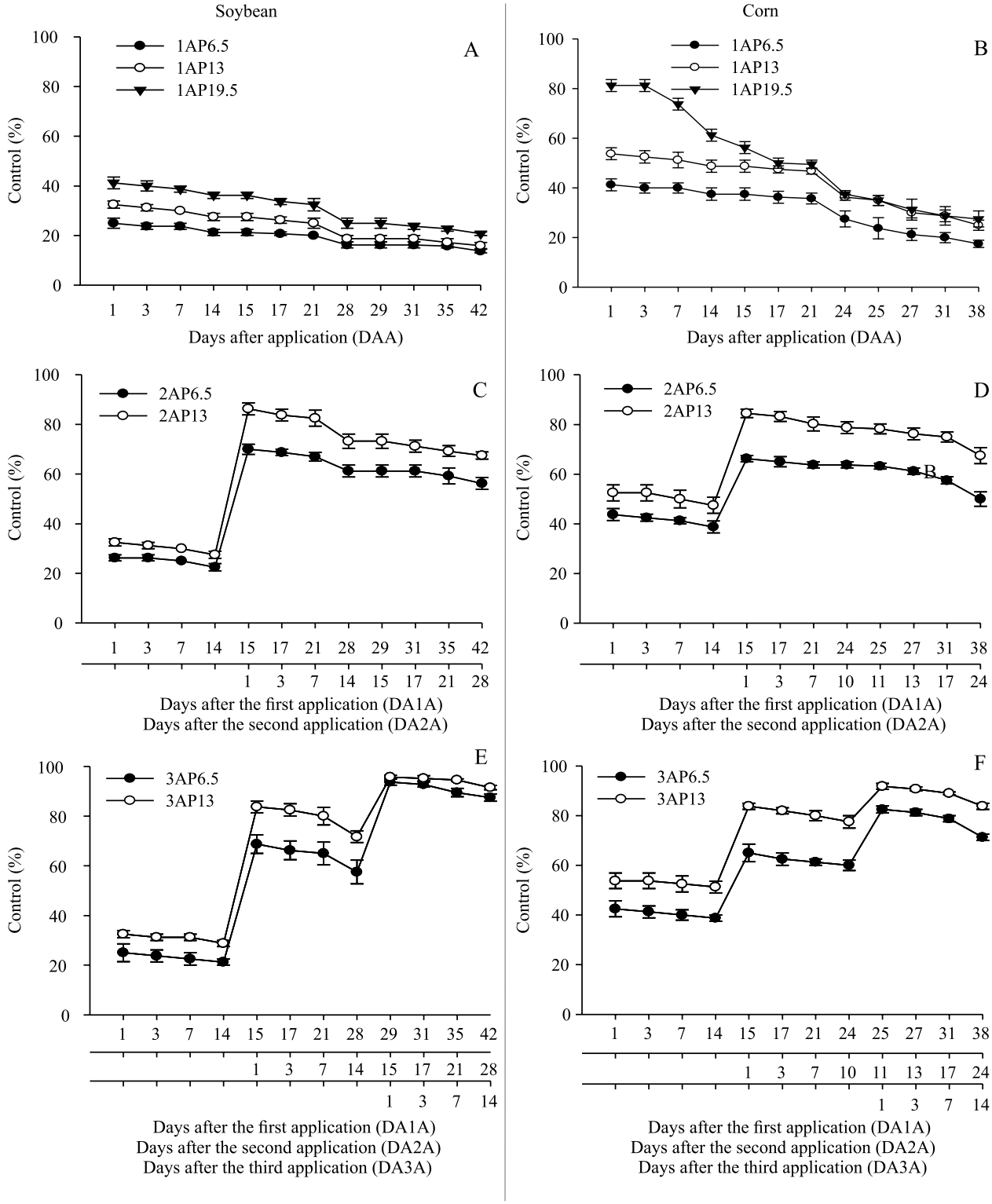

Figure 1. Weed control percentage following sequential applications of different pelargonic acid rates using directed spraying in soybean (A, C, E) and corn (B, D, F). 1AP6.5, single application at 6.5 kg ha^{-1}; 1AP13, single application at 13 kg ha^{-1}; 1AP19.5, single application at 19.5 kg ha^{-1}; 2AP6.5, two applications at 6.5 kg ha^{-1}; 2AP13, two applications at 13 kg ha^{-1}; 3AP6.5, three applications at 6.5 kg ha^{-1}; and 3AP13, three applications at 13 kg ha^{-1}. Vertical bars represent standard error of the mean.

increase in control efficacy as successive applications were performed, even at reduced bioherbicide rates (Figure 1 E).

In contrast to soybean results, a single application of 19.5 kg ha^{-1} pelargonic acid provided satisfactory control (>80%) for up to 3 DAA (days after the application) in corn (Figure 1 B). However, beyond this period, plants showed recovery from symptoms and apical bud regrowth. All other single-application treatments showed unsatisfactory weed control (<60%) from initial evaluations onward. The double sequential application of pelargonic acid at 13 kg ha^{-1} achieved 85% weed control only after the second application, however weed recovery from symptoms became evident by 7 DA2A (Figure 1 D). Consequently, the triple sequential application of pelargonic acid at 13 kg ha^{-1} increased weed control to >80% from 15 DA1A onward, and maintained this level through 38 DA1A (Figure 1 F).

The increased efficacy of sequential applications may be associated with repeated exposure of newly developed weed tissues to pelargonic acid. Weed regrowth following pelargonic acid application has also been reported in previous works, particularly when surviving tissues remain viable (Ganji & Andert, 2024).

In the present work, the first symptoms of injury (pale green spots followed by tissue desiccation) were observed on weed leaves within 30 min after application. Due to its contact mode of action, pelargonic acid causes rapid tissue destruction, limiting its translocation like the effect of photosystem I inhibitors (Traxler et al., 2023). Grass weeds exhibited greater regrowth capacity than broadleaf species.

Treatments were applied under suitable conditions for conventional pesticide spraying, at average air temperature ranging from 24.0 to 30.8°C, and relative humidity from 51.2 to 83.7% (Table 1). However, pelargonic acid efficacy is influenced by environmental conditions, particularly temperature and relative humidity, since higher temperatures and lower relative humidity may favor tissue desiccation and improve weed control. Campos et al. (2023) reported 60% control of *Digitaria sanguinalis* at temperatures from 17 to 22°C and 30% relative humidity. For *Solanum nigrum*, control reached 80% under the same conditions. Under 97% relative humidity, control decreased to below 50% for *D. sanguinalis* and 20% for *S. nigrum*.

The soybean field experiment showed a diverse weed community composed of 11 different species with variable distribution across plots (Figure 2 A). Plots treated with pelargonic acid showed a tendency toward reduced weed species richness, in comparison with the unhoed control (UHC), at both 62 and 136 days after sowing.

At 62 days after soybean sowing, the *Conyza* sp., *Leonurus sibiricus* L., *Phyllanthus tenellus* Roxb., *Sida* sp., and *Sonchus oleraceus* L. species were absent from plots that received three sequential applications at 13 kg ha^{-1} of pelargonic acid. These results indicate that the triple sequential application protocol showed the highest-suppression capacity of the initial weed flora present in the experimental area. Conversely, *Richardia brasiliensis* Gomes exhibited high tolerance to the bioherbicide applications, as it was present in all treated plots.

The greater species diversity observed at 136 DAS may be associated with new emergence flushes after treatment. This response is consistent with the low-soil persistence of pelargonic acid, which is rapidly degraded and, therefore, provides little residual control of subsequent weed emergence (Poiger et al., 2024).

The weed community in the corn experiment comprised 12 distinct species that − as observed also in the soybean trial – showed variable occurrence across plots (Figure 2 B). A clear reduction in species richness occurred with increasing application frequency, which is evident at both 55 and 145 DAS evaluations.

Monocotyledonous species dominated the weed community under experimental conditions (Figure 2 B), showing the reduced efficacy of the bioherbicide. Previous trials evidenced that pelargonic acid achieves complete control (100% efficacy) of dicotyledonous species, while exhibiting a significant reduction of efficacy (<60% control) against monocotyledonous weeds (Ogbangwor & Söchting, 2022).

At 55 DAS, plots receiving three applications of the highest rate of pelargonic acid showed 62.5% reduction in weed species richness. By contrast, the species diversity reduction at 145 DAS was only 33.3%. This differential efficacy between evaluations likely reflects new emergence flushes post-treatment, underscoring how sequential applications are critical to control both regrowth of initially suppressed weeds and new germinations from the soil seedbank.

Initial observations identified *Bidens* sp., *Conyza* sp., *Digitaria insularis*, *Raphanus raphanistrum*, and *Richardia brasiliensis* as the most susceptible species to the bioherbicide, which were completely absent in plots receiving triple sequential applications at both tested rates. Conversely, *Amaranthus* sp., *Avena strigosa*, and *Commelina benghalensis* showed high tolerance, persisting in nearly all treated plots.

These species-specific responses indicate that the efficacy of pelargonic acid and other natural bioherbicides may depend on weed community composition, as weed species differ considerably in their sensitivity to these compounds (Loddo et al., 2023; Brighenti et al., 2026). Species with greater regrowth capacity may therefore require repeated applications, whereas species that are more susceptible can be effectively suppressed with fewer treatments. Consequently, application frequency should consider not only weed growth stage, but also the dominant species within the weed community.

In the soybean field experiment, among single applications, only the 19.5 kg ha^{-1} rate effectively reduced weed dry mass by 45.18%, in comparison with the unhoed control (Table 2). In contrast, double sequential applications of pelargonic acid at 6.5 kg ha^{-1} resulted in the reduction of about 62.79%, while the 13 kg ha^{-1} rate resulted in the reduction of 73.19%, in comparison with the unhoed control.

The triple sequential application strategy proved most effective, reducing weed dry mass by 79.00% and 89.91% at 6.5 kg ha^{-1} and 13 kg ha^{-1} bioherbicide applications, respectively, in comparison with the unhoed control at 62 DAS.

During this period, triple sequential applications of 6.5 kg ha^{-1} pelargonic acid resulted in 61.63% lower-biomass accumulation, in comparison with a single 19.5 kg ha^{-1} application. These findings evidence that split applications of reduced herbicide rates can effectively suppress weed communities, supporting the superior long-term control observed with triple-application treatments (Figure 1 E) in comparison with single-application protocols (Figure 1 A).

At soybean harvest (136 DAS), weed dry biomass increased across all treatments; however, the most effective control treatments maintained the lowest-biomass accumulation rates, consistent with observations at 62 DAS (Table 2). These results highlight the critical role of soybean plants

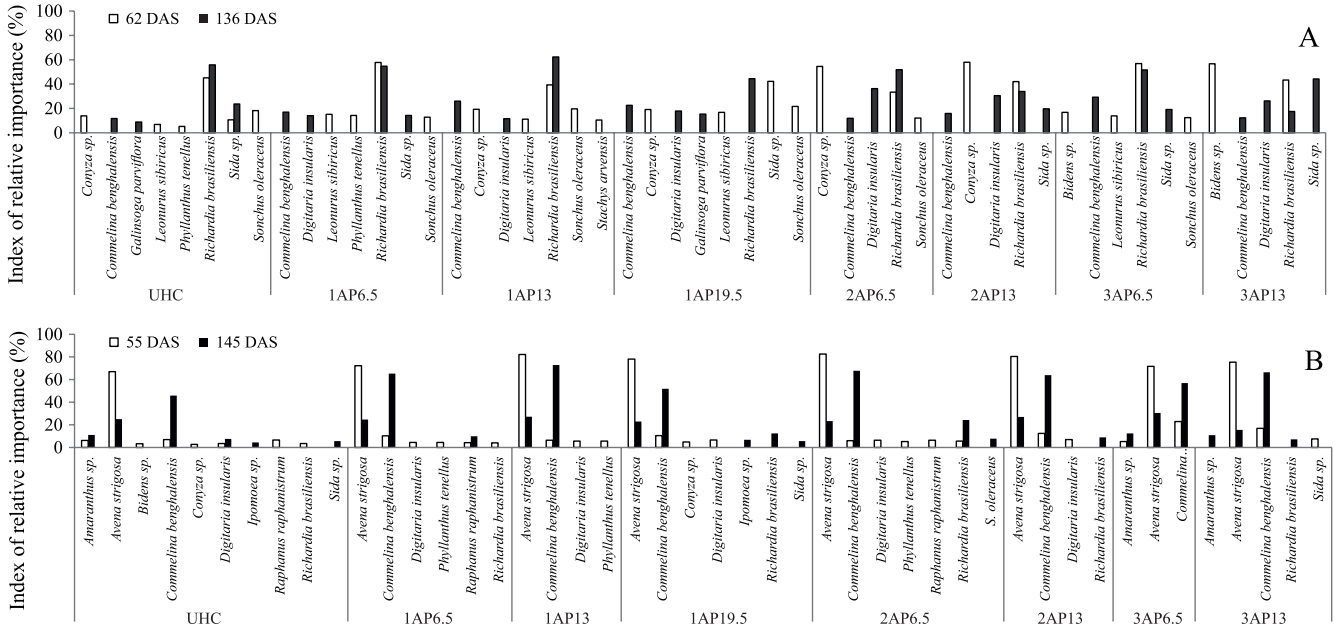

Figure 2. Index of relative importance of weeds following sequential applications of different pelargonic acid rates in soybean (A) and corn (B). UHC, unhoed control; 1AP6.5, single application at 6.5 kg ha^{-1}; 1AP13, single application at 13 kg ha^{-1}; 1AP19.5, single application at 19.5 kg ha^{-1}; 2AP6.5, two applications at 6.5 kg ha^{-1}; 2AP13, two applications at 13 kg ha^{-1}; 3AP6.5, three applications at 6.5 kg ha^{-1}; 3AP13, three applications at 13 kg ha^{-1}. DAS, days after sowing.

in complementing weed suppression following early-season weed management.

At 55 DAS in the corn field experiment, all pelargonic acid treatments significantly reduced weed dry biomass, with three sequential applications at 13 kg ha^{-1} providing the greatest reduction of 92.9%, in comparison with the unhoed control (Table 2).

At corn harvest (145 DAS), weed dry-biomass accumulation increased across all treatments; however, the most effective control protocols still maintained the lowest-accumulation rates, mirroring trends observed at the 55 DAS evaluation.

Phytointoxication percentage in soybean caused by the bioherbicide was considered very slight (< 7%), regardless of pelargonic acid application rate or frequency. By 42 DAA, plants showed significant recovery from initial symptoms (Figures 3 A, C, and E). These results indicate that protected directed-spray application effectively minimized direct contact with crop foliage, resulting in high-crop selectivity under the evaluated conditions. However, further studies involving different cultivars are necessary to determine whether this selectivity can be extended to other soybean and maize genotypes.

Protected directed spraying can be mechanized for inter-row weed management using tractor-mounted shielded sprayers, which allow of herbicide application between crop rows, while reducing spray exposure to the crop (Gholap & Tiwari, 2023).

Corn crop exhibited minimal phytointoxication from pelargonic acid applications, with injury levels remaining below 6%, regardless of application rate or frequency through 38 DAA (Figures 3 B, D, and F). Visible symptoms were characterized by persistent necrotic lesions at product contact sites, primarily on lower-canopy leaves, resulting from the herbicide contact activity.

The selectivity observed in the present study should therefore be interpreted primarily as positional selectivity provided by shielded directed spraying, rather than as intrinsic physiological tolerance of soybean and corn to pelargonic acid. The localized necrotic symptoms observed at sites with herbicide contact further supported this interpretation.

As a fatty acid-based contact bioherbicide, pelargonic acid rapidly disrupts cell membranes at the sites of application, causing cellular content leakage, tissue desiccation, and subsequent tissue necrosis (Preisler et al., 2026).

No significant differences were observed among treatments for soybean plant height or thousand-grain weight (Table 3), indicating that phytointoxication in treatments with poor control, caused by the bioherbicide and weed competition, did not negatively affect these agronomic traits.

However, yield data showed that treatments with two sequential applications of 13 kg ha^{-1} and three sequential applications of both rates (6.5 and 13 kg ha^{-1}) showed, on average, 23.77% higher productivity than

Table 2. Dry-weed biomass at different days after sowing (DAS) of soybean (*Glycine max*) and corn (*Zea mays*), as affected by pelargonic acid rates and application frequencies[(1)].

Treatment	Dry-weed biomass in soybean (kg ha^{-1})		Dry-weed biomass in corn (kg ha^{-1})	
	62 DAS	136 DAS	55 DAS	145 DAS
Hand-hoed control	-[(2)]	-	-	-
Unhoed control	770.71a	1,801.95a	2,044.89a	3,079.00a
Single application at 6.5 kg ha^{-1}	657.42ab	1,482.85ab	1,071.85b	2,435.62ab
Single application at 13 kg ha^{-1}	554.68ab	1,128.20bc	600.74cd	1,647.70bc
Single application at 19.5 kg ha^{-1}	422.44bc	858.17bcd	506.18cde	1,417.31bc
Two applications at 6.5 kg ha^{-1}	286.75cd	754.65cd	865.76bc	2,012.90abc
Two applications at 13 kg ha^{-1}	206.57cd	395.32d	341.06de	1,217.47c
Three applications at 6.5 kg ha^{-1}	162.08d	693.80cd	266.59de	1,523.02bc
Three applications at 13 kg ha^{-1}	77.77d	330.52d	145.17e	1,026.68c
Overall mean	392.30	930.68	744.96	1,794.96
Coefficient of variation (CV, %)	36.49	30.15	27.24	25.17

[(1)]Means followed by different letters differ significantly, by Tukey test, at 5% probability. [(2)]Weed biomass was not assessed in the hoed control due to the absence of weeds.

single applications and the unhoeded control (Table 3). Notably, these treatments did not differ statistically from the hoeded control, confirming the high selectivity of the crop, due to the protected directed-spray application method.

The critical period for weed control in soybean occurs between 20 and 50 days after crop emergence, when weed management should be effectively implemented (Rüdell et al., 2021). Consequently, the inadequate weed control, achieved with single bioherbicide applications up to 42 days after the first application, likely reduced soybean yield potential, due to weed competition during this critical growth phase.

Therefore, because of pelargonic acid contact mode of action and rapid foliar activity, the most effective and soybean-selective weed management strategies, during the critical prevention period, consisted of either double sequential applications at 13 kg ha^{-1}, or triple sequential applications at 6.5 and 13 kg ha^{-1}, using protected directed spraying.

Regarding corn plant height, reduction occurred exclusively in the unhoeded control (Table 3). These results contrast with previous studies which reported increased corn height under high *Cyperus rotundus* pressure, due to light competition-induced etiolation (Silva et al., 2015). The observed difference may be associated with temporary nitrogen limitation, caused by nitrogen immobilization during the decomposition of oat residues (the proceedings crop), given that the high C:N ratio of oat residue can reduce nitrogen availability to the subsequent corn crop (Alvez et al., 2024).

Only the single application at the lowest rate of pelargonic acid showed grain yield statistically equivalent to the unhoeded control, indicating detrimental weed competition when control efficacy was insufficient (Table 3 and Figure 1 B). All other treatments performed comparably to the hoeded control, consistent with effective weed suppression and minimal crop phytointoxication (Figure 3).

Under no-till corn establishment following oat residue, a single weed control intervention proves sufficient to prevent yield losses, during the critical prevention period (CPWC) between 23 and 31 days after emergence (Helvig et al., 2020). In this context, a single application of 13 kg ha^{-1} pelargonic acid maintained corn yields equivalent to the hoeded control (Table 3), despite providing only moderate visual weed control (Figure 1 B). This apparent discrepancy stems from the treatments 70.6% reduction in weed biomass sustained beyond the CPWC threshold (55 DAS), which effectively mitigated interspecific competition effects (Table 2).

Notably, double or triple sequential applications of pelargonic acid via shielded directed-spraying showed efficacy in managing weed populations, particularly during the crop's critical period of weed control (CPWC), while maintaining high selectivity. Dose and frequency of application should be determined based on operational cost assessments and target species

Table 3. Plant height and yield components of soybean (*Glycine max*) and corn (*Zea mays*), as affected by pelargonic acid rates and application frequencies[(1)].

Treatment	Soybean			Corn		
	Plant height (m)	1,000-grain weight (g)	Yield (kg ha^{-1})	Plant height (m)	1,000-grain weight (g)	Yield (kg ha^{-1})
Hand-hoed control	0.69	139.38	3,900.74a	1.32a	271.13	6,283.13a
Unhoed control	0.67	141.35	3,163.14b	1.20b	260.18	4,078.01c
Single application at 6.5 kg ha^{-1}	0.68	139.44	3,155.19b	1.27ab	260.55	4,105.10bc
Single application at 13 kg ha^{-1}	0.68	141.66	3,169.10b	1.31a	254.37	6,207.33a
Single application at 19.5 kg ha^{-1}	0.69	140.21	3,131.33b	1.32a	267.18	6,282.74a
Two applications at 6.5 kg ha^{-1}	0.68	142.56	3,759.58ab	1.31a	263.86	5,837.39ab
Two applications at 13 kg ha^{-1}	0.68	139.59	3,892.79a	1.30a	260.38	6,141.36a
Three applications at 6.5 kg ha^{-1}	0.68	140.04	3,934.54a	1.30a	257.73	6,345.57a
Three applications at 13 kg ha^{-1}	0.69	139.32	3,886.83a	1.30a	254.72	6,421.37a
Overall mean	0.68	140.39	3,554.81	1.29	261.12	5,744.66
Coefficient of variation (CV, %)	3.53	2.13	8.29	2.77	3.26	12.67

[(1)]Means followed by different letters differ significantly by the Tukey test, at 5% probability.

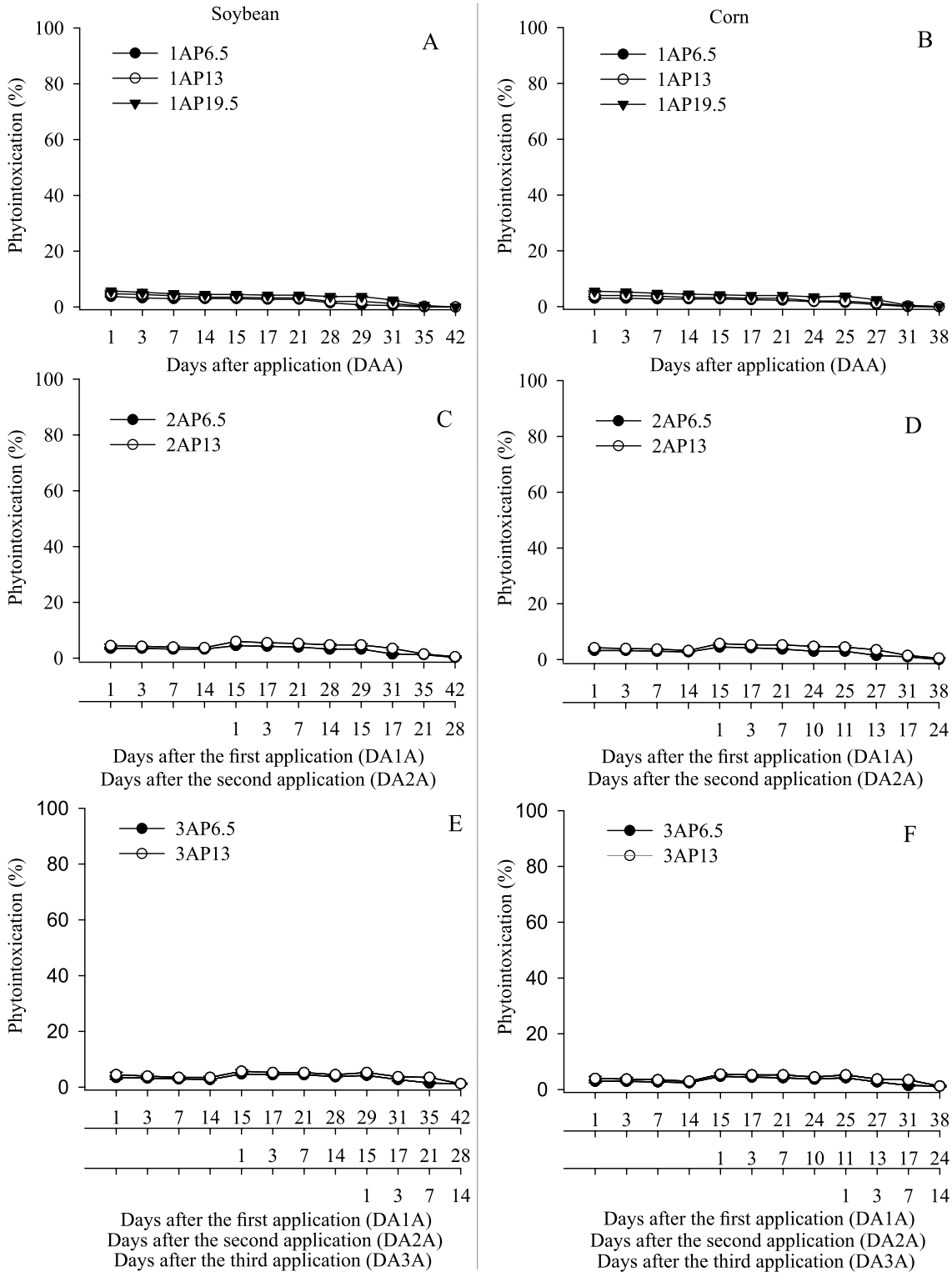

Figure 3. Phytointoxication percentage in soybean (*Glycine max*) and corn (*Zea mays*), following sequential applications of different pelargonic acid rates using directed spraying. Applications: 1AP6.5, single application at 6.5 kg ha^{-1}; 1AP13, single application at 13 kg ha^{-1}; 1AP19.5, single application at 19.5 kg ha^{-1}; 2AP6.5, two applications at 6.5 kg ha^{-1}; 2AP13, two applications at 13 kg ha^{-1}; 3AP6.5, three applications at 6.5 kg ha^{-1}; 3AP13, three applications at 13 kg ha^{-1}. Vertical bars represent standard error of the mean.

tolerance thresholds. This approach may contribute to integrated and sustainable weed management strategies, while further economic assessments are needed to determine its viability in soybean and maize production systems.

Although pelargonic acid has shown effective weed control and high crop selectivity under shielded directed spraying conditions, further researches still need to better understand its potential effects on non-target organisms. Additional research should evaluate possible long-term impacts on aquatic organisms, soil biodiversity, and nontarget vegetation, to support the safe and sustainable use of this bioherbicide.

Future research should also focus on optimizing pelargonic acid efficacy through improved application technologies and adjuvant use, as well as investigating more economical methods for pelargonic acid synthesis, to reduce production costs and facilitate this acid adoption on a larger scale in agriculture.

Conclusions

1. Sequential applications of pelargonic acid via protected directed spraying provide efficient weed control while maintaining crop selectivity in soybean (*Glycine max*) and corn (*Zea mays*).

2. The most efficient strategies consist of three applications at 6.5 kg ha^{-1} or two applications at 13 kg ha^{-1} in soybean, and a single application at 13 kg ha^{-1} on maize, with no reduction of grain yield under the evaluated conditions.

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Data available upon request: research data are only available upon reasonable request to the corresponding author.

Declaration of use of AI technologies

During the preparation of this work, the authors used ChatGPT (OpenAI) in order to assist with English-language revision. After this use, the authors reviewed and edited the content as needed and takes full responsibility for it.

Conflict of interest statement

The authors declare no conflicts of interest.

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